Hawt Hovercrafts!!

Facilitation Time: 110 minutes

SAFETY INFORMATION Minimal safety concerns although activities in this lesson involves more movement and therefore teachers should be mindful of the spatial arrangement of the classroom to help minimize potential injuries.

ESSENTIAL QUESTION/S How can we predict what outer space conditions will be like without never having been there? (How do we help astronauts prepare for the foreign environment they will have to work in?)

SUMMARY OF ACTIVITIES

- Activity 1: Newton's Laws of Motion Rocket Balloon Demo (Day 1, D4)
- Activity 2: (ULTIMATE) Hovercraft Design Challenge Series
  - CD Hovercrafts *only* (Day 1, D4)
  - Introduce different hovercraft materials for students to experiment with (Day 2, D5)
- Activity 3: (ULTIMATE) Space Speed Race 2019 and/or Hovercraft Show/Games (Day 2, D5)

SCIENCE STORYLINE

Your dear friend, Duke Dreamwalker, has invited you to the annual (Star Wars) Space Speeder Race but oh drat! You don't actually have a speeder (i.e. hovercraft) to enter…! Well luckily you have the next couple days to learn the science behind how hovercrafts work whilst personally going through the engineer/design process to design an amazing (hot) hovercraft prototype that can be entered into the "(**ULTIMATE Space Speeder Races (Tournament) 2019**"!!

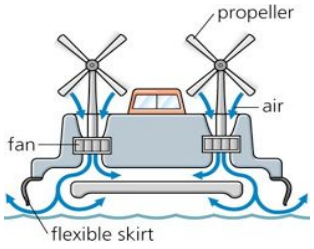
VISUALS

Two astronauts practice space rescue over the Precision Air Bearing Platform (PABP) at the NASA Johnson Space Center. (The PABP is like a giant air hockey table.)

IMPORTANT INFO TO KNOW

Hovercrafts (a.k.a. air-cushion vehicles (AVC)), are vehicles that move by hovering in the air on a cloud of pressurized air. Hovercrafts generate higher air pressures by trapping a large amount of air underneath its hull through the efforts of its blowers & flexible skirt(s). The resulting pressure differential between the air trapped under the hovercraft and the air surrounding the hovercraft is what gives the hovercraft its ability to float above the ground. Depending on the size & power of the fans, hovercrafts can lift anywhere from 6 inches to over 7 feet in the air!

Hovercrafts generate minimal friction when moving through the air, and this greatly mirrors the microgravity conditions that exists in outer space. Because of this, NASA takes advantage of this same principle with its Precision Air Bearing Platform to help train its astronauts on how to move & maneuver objects in space.



Written 11.20.18 by Elaine Wu)

OBJECTIVES

Objective: *The learner will know and be able to…*	**Activity**	**Assessment:** *What will the learners produce as evidence of meeting the objective?*
Create a balloon-powered hovercraft prototype(s).	2	Balloon-powered hovercrafts that are designed to be able to accomplish a series of tasks.
Record data measuring hovercraft's effectiveness and troubleshoot prototype(s) based on quantitative & qualitative observations.	2	Video and picture documentation of observations; written observations in notebook.

WELCOME

1) Welcome back Astronauts / Aerospace Engineers! Thanks to all your hard work over the week we've successfully travelled to the mysterious Planet IMSA to visit with our dear, old friend, Duke Dreamwalker.
2) So the minute we landed on Planet IMSA, I get a call from my friend "Duke (Dreamwalker?) Sleepwalker" – (we totally go way back since like, 1977) - and he asked if I wanted to come over and race speeders with him? And I was totally like, "Yeah! I want to come!" But then I realized that I don't actually have a speeder (a.k.a. hovercraft to you Earthlings.)
3) Now it looks like I'm going to have to ask for your help, *again*! For the next 2 days, we are going to be exploring the science of hovercrafts and experimenting with different science concepts that will allow us to build the most ultimate hovercraft ever!!

WARM UP (Discussion) (Estimated Time = 5 minutes)

1. What are hovercrafts? *(Answers will vary… "Things that can hover!" Vehicles that "float" on a cushion of air and can move over many different kinds of surfaces - land, water, ice, mud, etc.)*
2. Where have you seen hovercrafts before? What do you think people use hovercrafts for?
3. How do you think hovercrafts work? (Teachers should wait until the end of the class period to fully address this/provide their answers…)
4. What factors do you think will affect how well a hovercraft can work? (*Weight, load, weather, surface/terrain that you are hovering over, elevation,* ***friction…)***
5. "But wait, if we need to design this hovercraft to work on a different planet, how can we tell whether it will work or not…? Has anyone here been to space, perhaps,?" (*chances are not many people will raise their hand…*)
6. "Hmm, not many people have been to space but now raise your hand if you have ever heard of a guy called Sir Isaac Newton?" (*hopefully most will be familiar with this name…*)
7. "What if I told you that even though none of us have ever (technically) been to space, we can still predict and understand what it would be like to move in space so long as we have a solid understanding for how Newton's 3 Laws of Motion work. (Isn't it amazing/crazy to think that the laws of physics we follow here on Earth are the same ones you would follow in other parts of the universe?!)
8. Review Newton's 3 Laws of Motion. (***Newton's 1st Law*** *= an object in motion will stay in motion and an object at rest will stay at rest unless an unbalanced force acts upon it;* ***Newton's 2nd Law*** *= Force = Mass x Acceleration - (the greater the force, the greater the acceleration, the greater the mass, the lesser the acceleration);* ***Newton's 3rd Law*** *= every action has an equal & opposite reaction*)

ACTIVITY ONE (Estimated Time = 15 minutes)

MATERIALS

Per Class:
1 - 20' length of jute twine
1 - 20' length of cotton twine
1 - 20' length of curling ribbon
3 - drinking straws
2 - 7" balloon
2 - 11" balloon
1 - painters tape roll
1 - scissors
5 - sheets of printer paper
10 - metal washers
5 - meter sticks

CLASSROOM SETUP

- ❏ Locate 2 stable structures/supports - (e.g. chairs, pillars, door handles) - across the room where strings can be tied and balloon will be able to pass through without obstruction.

(*Note: Try to get string to stretch for (at least) 12 feet, if possible.)

- ❏ String a straw through (at least) one type of string then tie ends of string to the supports - (if space allows, can pre-tie all 3 types of string.)

WHAT TO DO

(*NOTE: This activity is to be done as an interactive class demo with students giving suggestions for possible variables to test/ experiments to conduct given the initial experimental set-up...)

1. It's time to see some of Newton's Laws in action! Behold, the amazing Newton Rocket Balloon!!
2. Blow up a 7" balloon, tape to straw at one end of the string and then ask students to predict what's going to happen once air in balloon is released.
3. Release balloon and record distance balloon traveled across the string - (this distance can serve as the "control distance" which all other trials will be measured against.
4. Ask students what areas of this initial setup they can improve upon in order to get balloon to travel further and/or faster - (this question should organically lead to a discussion on possible experimental variables that can be tested…)
5. Repeat demo procedure but with tweaks to the setup in order to test different experimental variables - (e.g. tape washers onto blown-up balloon in order to see effect of mass on acceleration, change the string type to see how friction impacts distance traveled by balloon, etc…)

OPPORTUNITY FOR INQUIRY

Possible variables that can be tested with demo include:
1) Thrust - (air pressure/volume in balloon)
2) Mass of Balloon - (can add extra mass with metal washers)
3) Friction - (experimenting with different types of string with varying degrees of friction)
4) Aerodynamic Shape - (can use paper & tape to change the rounded shape of the original balloon…)

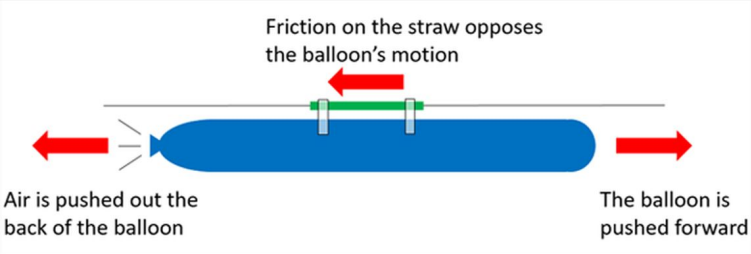
(*Encourage students to come up with the experimental variables they'd like to test first but if students are having a hard time thinking of possible variables to test, then can write up list of variables and have students devise ways to test those variables with the provided/available materials…)

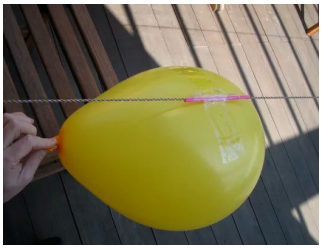
TIPS FOR TEACHERS

Before each trial, remember to ask students to make predictions/hypotheses on what they think will happen with each new experimental adjustment/tweak - (e.g. balloon will travel 6 inches more than the original control distance because _____.)

The demo can/should involve student volunteers - (some roles students can play include measuring the

distance travelled by balloon, assisting with tape, tying string, suggesting experimental setups, etc…)





WHAT'S HAPPENING

Newton's Rocket Balloon demo is a succinct way to show all 3 of Newton's Laws of Motion in action and help students visualize some of the physics propelling the hovercrafts they will be making.

1. 1st Law of Motion: a) An unbalanced force - (air from the balloon) - is needed to get the balloon moving, b) Friction and/or some impeding obstacle are some examples of unbalanced forces that will eventually slow & stop the balloon once it's in motion.
2. 2nd Law of Motion: a) The greater the air pressure inside the balloon, the more the hovercraft will be able to accelerate, b) The greater the mass of the balloon, the more force will be necessary to get it to accelerate/move
3. 3rd Law of Motion: a) The action force caused by the air being released from the balloon creates a reaction force which lifts the hovercraft off the surface.

(Teacher can emphasize the fact that the laws of physics that apply to us on Earth are the same ones that you can expect to experience in space, which is why we can accurately predict what to expect when in outer space...)

ACTIVITY TWO (Estimated Time = 30 minutes (Day 1, D4); 35 minutes (Day 2, D5))

MATERIALS

Per Person:

Day 1 (D4) - (save/reuse materials for Day 2):
1 - CD
1 - pop-top bottle cap
1 - 7" balloon
1 - 11" balloon
1 - Student Challenge Checklist
1 - gallon-sized plastic bag - (for storing materials/hovercrafts from Day 1)

Day 2 (D5) - (New materials in addition to ones used on Day 1):

CLASSROOM SETUP

Day 1:
- ❏ Have materials ready for easy & efficient distribution

Day 2:
- ❏ Break poster tack sticks in half - (should get 8 pieces per pack)
- ❏ Have materials ready for easy & efficient distribution
- ❏ Write Available Materials Quota on board:

1 - 7" paper plate
1 - 9" paper plate
1 - 6" foam plate
1 - 9" foam plate
1 - 10 ¼" foam plate
1 - ½ stick (⅜ oz.) of poster tack
5 - bendy straws
5 - coffee stirrers
5 - jumbo straws
1 - 3' length of cotton twine
1 - 7" balloon - (students can have up to 2 from Day 1)
1 - 11" balloon - (students can have up to 2 balloons)
2 - sheet of tracing paper
2 - sheet of printer paper
1 - scissors

Per Table - (**use for both Day 1 & 2**):
20 - metal washers (for weight/load testing)
2 - masking tape rolls
2 - balloon pumps
1 - permanent marker - (for labeling gallon-sized bags with student names)

Per Class - (**use for both Day 1 & 2**):
2 - beach towels (for friction testing)

(New) Day 2 Hovercrafts Materials

1 - 7" paper plate
1 - 9" paper plate
1 - 6" foam plate
1 - 9" foam plate
1 - 10" foam plate
1 - ½ stick of poster tack
5 - bendy straws
5 - coffee stirrers
5 - jumbo straws
1 - cotton twine
1 - 7" balloon
1 - 11" balloon
1 - sheet of tracing paper
1 - sheet of printer paper
1 - scissors

WHAT TO DO

Day 1 (D4)

1. Pass out Day 1 materials and allow students 30 minutes to construct CD hovercraft and try to accomplish the challenges listed on Student Challenge Checklist
2. Use last 5-10 minutes of class to debrief about what students observed/learned from making their CD hovercrafts, how far along they got on their mission checklist, and what materials they wish they had access to to improve upon their hovercraft design...

Day 2 (D5)

1. The space missions continue in order to get us ready for the Ultimate Space Speed Race!
2. Introduce new materials available for students to use to make their hovercrafts - (reference materials quota list written on board…) - then

OPPORTUNITY FOR INQUIRY

If students seem unmotivated to continue trying to accomplish suggested hovercraft design missions, you can recommend that they come up with their own challenges and/or suggest that they design a game that can be played with their hovercrafts.

TIPS FOR TEACHERS

You can use Completion Check column on Student Challenge Checklist to help keep students on track/on task as well as (hopefully) incorporate a sense of excitement & motivation for completing "space missions."

Remember to write student names on plastic bags so supplies don't get mixed up - (don't forget to collect STudent Challenge Checklist so can be reused for Day 2)

redistribute labeled bags of supplies from previous day.

3. Allow students 35 minutes to create new hovercrafts and/or update CD hovercrafts from Day 1 with using newly available materials.
    a. Students should continue to use Student Challenge Checklist and try to improve on the records set from Day 1.

Example Paper Plate Hovercraft:
https://www.youtube.com/watch?v=U-ttfMKaRqE

Try to encourage students to make unique hovercrafts - (i.e. ideally, every person's hovercraft will look/operate slightly differently…)

WHAT'S HAPPENING

The following are (some of the) variables that can impact the effectiveness of a hovercraft:

- **Air Pressure** = the force exerted by **air** (either compressed or free-flowing) on any surface it is in contact with.
    - Students will be able to experiment with this variable by determining how much air they wish to fill their balloons with. The more air they add, the greater the air pressure but could also present problems with the balance/weight distribution of the craft...

- **Friction** = the resistance force that is generated anytime multiple surfaces come in contact and slide against each other.
    - Students will be able to experiment with this variable (primarily) through the type of surface that they choose to fly their hovercrafts over - (e.g. hardwood floor, carpet, table, etc…) The amount of friction in the surface that the hovercraft is hovering over affects the hovercraft's flight because irregular, uneven terrain makes it easier for air in the air cushion to escape; which then lowers the pressure under the craft and diminishes the pressure difference needed for the hovercraft to fly. Flying over smooth, flat (relatively frictionless) surfaces allows for the air cushion to form a lot more easily.

- **Hovercraft (Aerodynamic) Design** = the choices students make in the shape, size, material choices, and layout of their hovercrafts (among other possible variables) that will ultimately affect the efficiency of their hovercrafts.

ACTIVITY THREE (Estimated Time = 10-15 minutes)

MATERIALS

Per Student:
Hovercraft Prototype(s) from Activity 2

Per Class:
1 - painters tape roll - (for marking boundaries, if necessary)

CLASSROOM SETUP

- ❑ Clear adequate amount of space in classroom - (or secure space outside of classroom, e.g. in an open hallway/common area…) - for students to be able to race hovercrafts with minimal obstructions.

WHAT TO DO

1. This final mini activity is intended to be an opportunity for students to show-and-tell on their hovercraft inventions.
    a. Depending on group dynamics of class, can either have this time be a series of competitive races - (bracket / king-of-the-hill style), or simply use the time to allow students to demonstrate how their hovercrafts work in front of their peers and share their findings/creative innovations...

(If space allows, could potentially also use this time to have a "hovercraft dance party" where multiple hovercrafts are simultaneously zooming at once!)

OPPORTUNITY FOR INQUIRY

Can encourage students to come up with their own hovercraft games - (e.g. "bumper hovers", hovercraft soccer, etc....)

TIPS FOR TEACHERS

Be mindful of setting clear expectations for where students should/shouldn't be during this activity - (e.g. only students demoing/racing their hovercrafts should be in the center of the room/inside the boundaries and everyone else should be outside the lines.)

CHECK FOR UNDERSTANDING

1. Possible Questions to Ask: 1) How do hovercrafts work? (*Hovercrafts are able to float because they create & trap a pressure differential underneath to get them to levitate. They work similarly to how an air hockey table works*.) 2) What were some of the obstacles you had to overcome during your engineering design process? (How did you overcome them?) (*Answers will vary but many may bring up the friction challenge of trying to get their hovercrafts to work on surfaces with more friction…)*, 3) What materials do you wish you had access to so you can make your hovercraft prototype even better? 4) What additional science knowledge would you like to learn more about so that you can further improve upon your design? (*Answers will vary…*)
2. If time allows, can show following videos to help wrap up theme of camp and (hopefully) leave them on an inspirational note...:
   Extreme Hovercraft Racing: https://www.youtube.com/watch?v=h18FOjnv6YY
   Star Wars Episode 1 - Pod Race Finale: https://www.youtube.com/watch?v=t8O5AihRSLU

TERMINOLOGY

Friction - the resistive force generated between two materials/surfaces that are in contact rubbing/sliding against each other.

Microgravity - the state of near-weightlessness due to a very weak gravitational pull

STANDARDS

NGSS-MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

NGSS-MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

NGSS-MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

REFERENCES

1. Balloon Rocket Demo: https://sciencebob.com/make-a-balloon-rocket/
2. https://www.explainthatstuff.com/hovercraft.html
3. https://www.nasa.gov/sites/default/files/hovercraft.pdf
4. https://www.jpl.nasa.gov/edu/teach/activity/hovering-on-a-cushion-of-air/

MATERIALS

Item Name	Picture of Item	Description	vendor	TOTAL Amt	Unit
Painters Tape		for marking boundaries on floor		1	roll
Masking Tape				10	roll
Balloon Pump				20	pumps
5/16" Metal Washers		Used as weights for load capacity testing	Menards	100	washer
Scissors				20	scissors
Beach Towel		https://www.orientaltrading.com/flamingo-beach-towel-a2-13830841.fltr?keyword=towel (Price = $9.99 / towel)	Oriental Trading	2	towels
Projector				1	projector
Laptop w/ WiFi Connection		Extreme Hovercraft Racing: https://www.youtube.com/watch?v=h18FOjnv6YY Star Wars Pod Race: https://www.youtube.com/watch?v=t8O5AihRSLU		1	laptop
Permanent Markers				5	marker
REUSABLE ABOVE // CONSUMABLE BELOW					
Student Challenge Checklists		https://docs.google.com/document/d/1nKQbsclavfOdmthqO730BOWlsgbvlwHdj8nS1bRkLW4/edit?usp=sharing		20	copies
CD		https://www.menards.com/main/electrical/electronics/computer-accessories/shop-all-computer-accessories/xtreme-cd-r-compact-disc-25-pack/11251/p-1444436446991-c-13536.htm?tid=74500708879888720&ipos=1 (Price = $8.89 / 25)	Menard's	20	CD
7" Balloons		https://www.schoolspecialty.com/hygloss-balloons-assorted-colors-1595463 (Price = $13.12 / 144)	School Specialty	45	balloon

11" Balloon		https://www.schoolspecialty.com/balloon-1321817 (Price = $17.54 / 144)	School Specialty	45	balloon
Pop-Top Bottle Caps			Oriental Trading	20	cap
Gallon-Sized Plastic Bags				20	bag
6" Foam Plates		https://www.uline.com/Product/Detail/S-14754/Plates-and-Bowls/Foam-Plates-9 (Price = $42 / 500)	ULine (Sam's Club)	25	plate
9" Foam Plates		https://www.samsclub.com/sams/dart-concorde-foam-plates-9-500-ct/prod6880012.ip?xid=plp_product_1_9 (Price = $0.05 / plate)	Sam's Club	25	plate
10 ¼" Foam Plates		https://www.samsclub.com/sams/plate-foam-cmprt10-25wht/prod14420226.ip?xid=plp_product_1_4 (Price = $0.07 / plate, $36.94 / 500 plates)	Sam's Club	25	plate
7" Paper Plates		https://www.uline.com/Product/Detail/S-18497/Plates-and-Bowls/Uline-Paper-Plates-7-Medium-Weight (Price = $16 / 250)	ULine (Sam's Club)	25	plate
9" Paper Plates		https://www.uline.com/Product/Detail/S-17274/Plates-and-Bowls/Uline-Paper-Plates-9-Medium-Weight (Price = $27 / 330)	Sam's Club	25	plate
Tracing Paper, 9" x 12"		https://www.schoolspecialty.com/sketch-and-trace-paper-205547 (Price = $19.49 / 500 sheets)		40	sheets
Poster Tack		https://www.schoolspecialty.com/scotch-lightweight-mounting-putty-blue-1494645 (Price = $2.32 / 3oz. pack)	School Specialty	3	(3oz.) packs
Unwrapped Jumbo Straws, 7" 3/4"		https://www.vanscosupply.net/unwrapped-jumbo-straws-7-3-4-polypropylene-translucent-250-bx-50-bx-carton.html.html	Vansco Supply	100	straws
Unwrapped Stir Straws, 5 ¼"		https://www.vanscosupply.net/unwrapped-single-tube-stir-straws-5-1-4-red-1000-pack.html.html	Vansco Supply	100	straws
Bendy Straws				100	straws
Cotton Twine		Used for rocket balloon demo & student prototypes...		80	feet
Tracing Paper		https://www.orientaltrading.com/300-series-tracing-paper-pad-a2-13652136.fltr?keyword=tracing+paper (Price = $6.99 / 50 sheets)	Oriental Trading	40	sheet
Printer Paper				40	sheet

ADVANCED PREP (list any preparation required for the lesson, such as printing needs and special material prep)

- ❏ (Highly) Recommended that teacher practices doing the balloon rocket demo ahead of time so s/he can become familiar with blowing up the balloon and taping it to the straw without popping it.
- ❏ Print out Student Challenge Checklists - (1 / student): https://docs.google.com/document/d/1nKQbsclavfOdmthqO730BOWlsgbvlwHdj8nS1bRkLW4/edit?usp=sharing
- ❏ Cut cotton twine into 3' lengths - (1 / student)